

CHARACTERIZATION OF APOLLO REGOLITH BY X-RAY AND ELECTRON MICROBEAM TECHNIQUES: AN ANALOG FOR FUTURE SAMPLE RETURN MISSIONS

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Introduction: The Apollo missions collected 382 kg of rock and regolith from the Moon; ~1/3 of the sample mass collected was regolith. Lunar regolith consists of well mixed rocks, minerals, and glasses <1 cm in size. The majority of most surface regolith samples were sieved into <1, 1-2, 2-4, and 4-10 mm size fractions; a portion of most samples was reserved unsieved. The initial characterization and classification of most Apollo regolith particles was done primarily by binocular microscopy. Optical classification of regolith is difficult because (1) the finest fraction of the regolith coats and obscures the textures of the larger particles, and (b) not all lithologies or minerals are uniquely identifiable optically. In recent years, we have begun to use more modern x-ray beam techniques [1-3], coupled with high resolution 3D optical imaging techniques [4] to characterize Apollo and meteorite samples as part of the curation process. These techniques, particularly in concert with SEM imaging of <1 mm regolith grain mounts, allow for the rapid characterization of the components within a regolith.

Discussion: Micro computed tomography (micro-CT) measures the attenuation of x-rays passing through a sample, producing 3D maps of a sample's components. Scans of meteorites and Apollo samples have shown that lithic clasts can be identified in polymict breccias, the mineralogy of igneous samples characterized, and rock textures determined [1-3]. Micro-CT scans do not give direct compositional information, however. Micro x-ray fluorescence (micro-XRF) scans can give quantitative major- and minor-element compositions of the surface of regolith particles. Recent micro-XRF analyses of 2-4 mm Apollo samples, when compared to previous analyses of the same particles [5], have shown relatively quick (1-2 minute) micro-XRF analyses can reliably measure the bulk major element composition of the particles, and by inference their lithologies. The high energy nature of micro-XRF and especially micro-CT allows these scans to be done on samples bagged in Teflon to protect their pristinity. X-ray and BSE imaging by SEM of regolith grain mounts can quickly characterize the texture and composition of 1000s of regolith particles. Although SEM analyses are destructive, these grain mounts require very little mass (~10 mg). Bulk Apollo regolith is a good analog for future asteroid sample return missions, and the techniques described here will likely play a role of the preliminary examination of samples returned by missions like OSIRIS-REx or Hayabusa 2.

References: [1] Zeigler R.A. (2014). *LPSC 45*: abstract #2665. [2] Almeida N. V. et al. (2014) *MAPS 77*: abstract #5033. [3] Smith C. L. (2013) *MAPS 76*, abstract #5323. [4] Blumenfeld E. H. et al. (2014) *MAPS 77*: abstract #5391. [5] Korotev et al. (2011) *GCA 75*, 1365-1402.